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(54) Abstract Title
Laminated heat exchanger

(57) A heat exchanger is constructed by laminating a plurality of tubes (2) constructed by a pair of metal plates (4) connected to face each other. A distance (H1 × 2) between the pair of metal plates (4) defined by a center rib (49) is set to be larger than the distance (H2 × 2) defined by outer peripheral ribs (55). By this, the center ribs (49) of the pair of metal plates (4) can contact with each other b fore the outer peripheral ribs. The distance (H1 × 2) is larger than the distance (H3) and the distances (H4, figure 9) and (2 × H5, figure 10).

FIG. 8

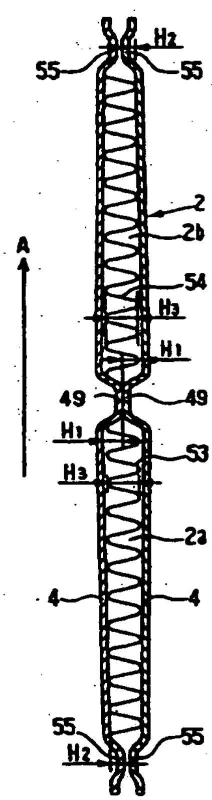

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FIG. 1

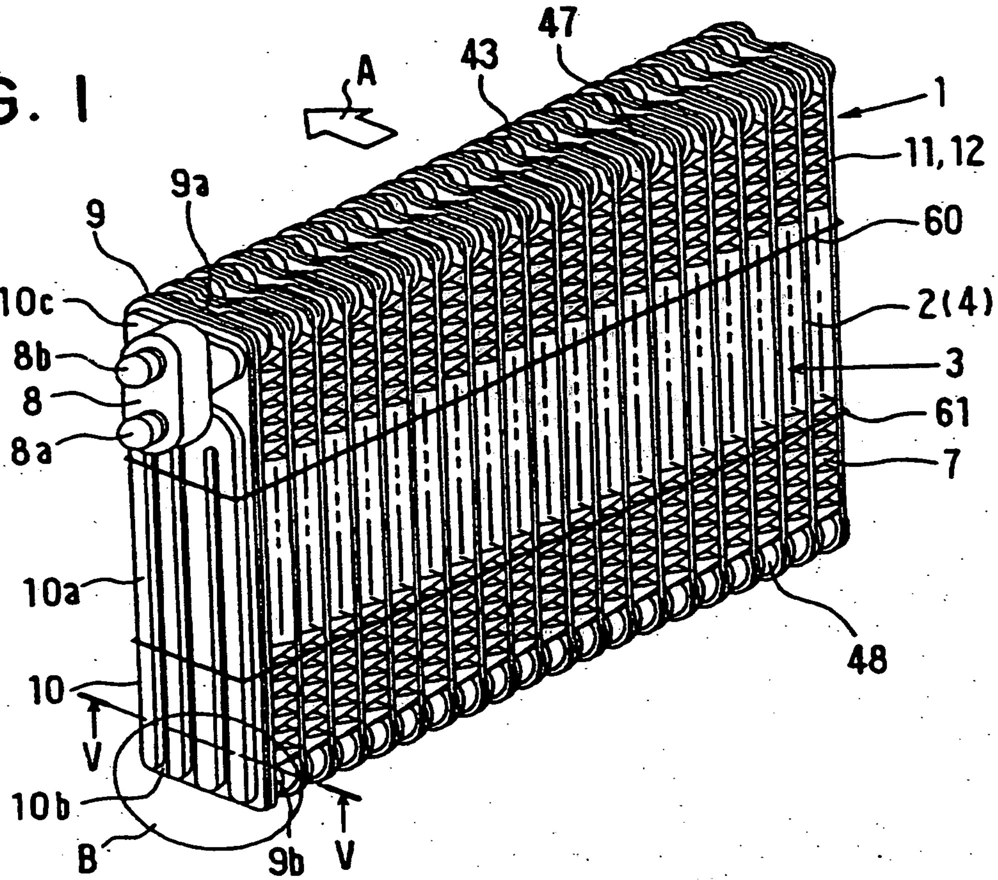
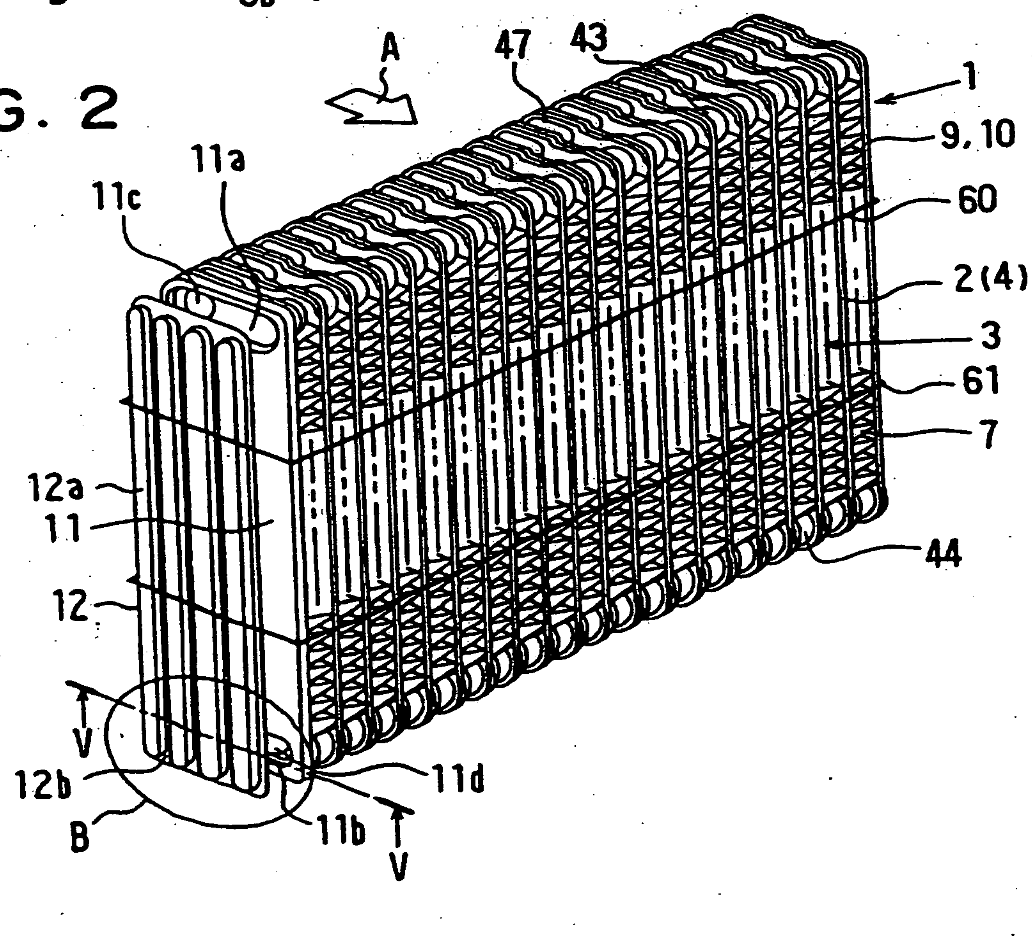

A
47
43
1
11,12
9a
9
60
10c
2(4)
8b
3
8
61
8a
7
10a
48
10
V
10b
B
9b
V

FIG. 2


A
47
43
1
9,10
11a
11c
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2(4)
3
61
7
12a
11
44
12
V
12b
11d
B
11b
V

FIG. 3

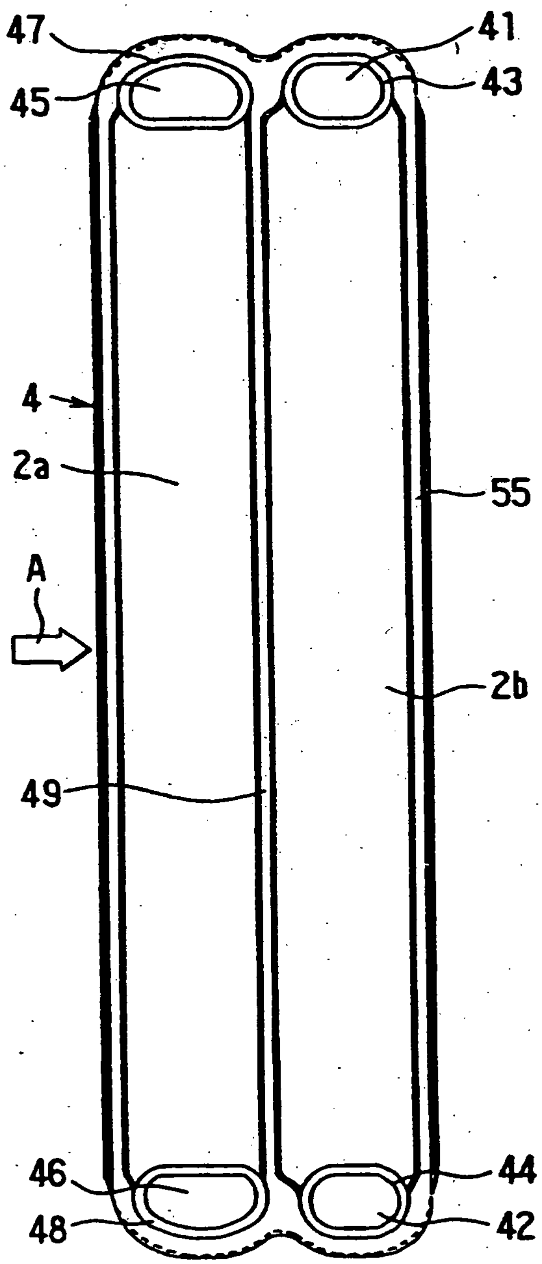


FIG. 4

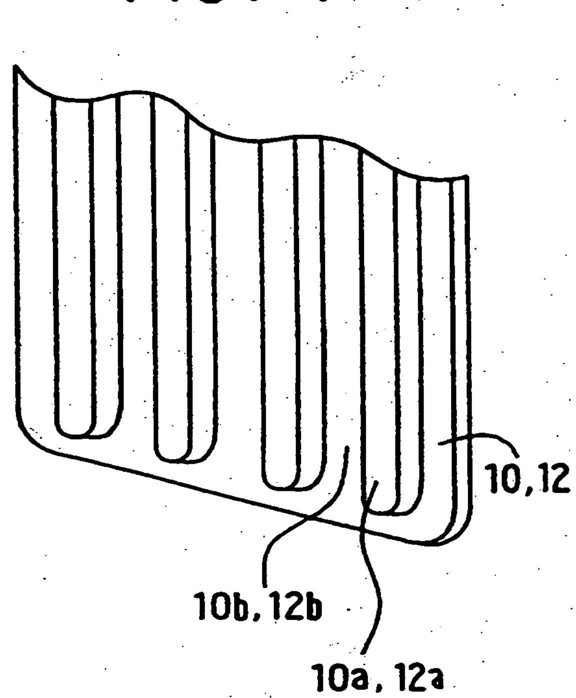


FIG. 5

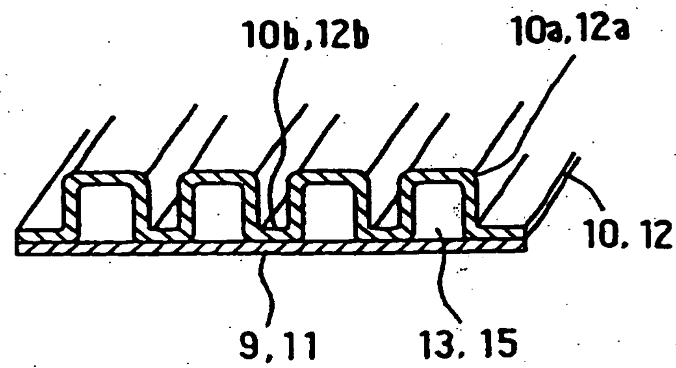


FIG. 6

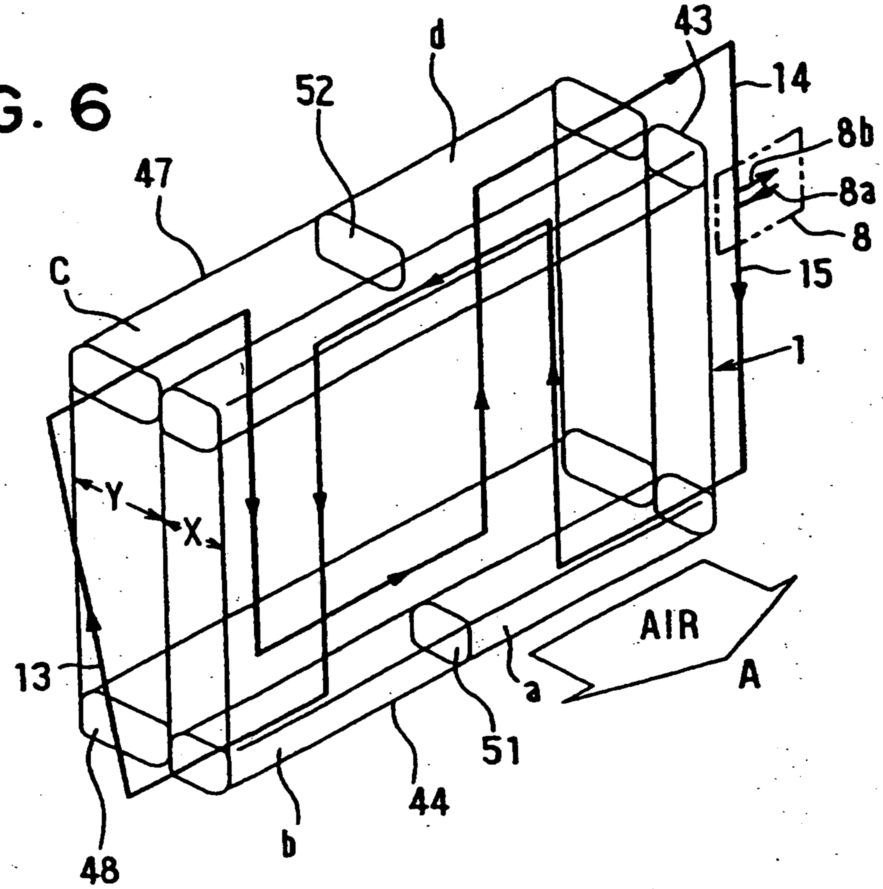

d
43
14
52
8b
47
8a
8
C
15
1
Y
X
AIR
13
a
A
51
48
b
44

FIG. 7

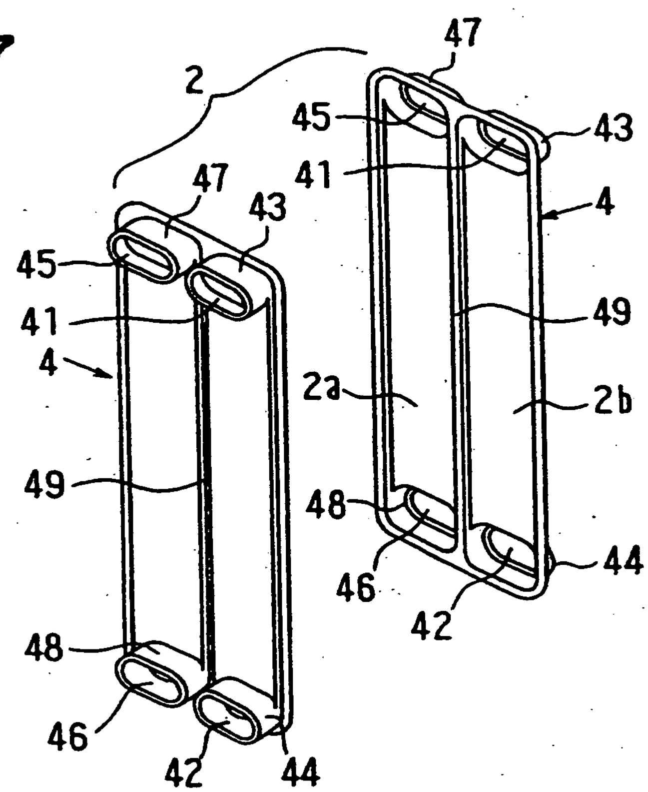

47
2
45
43
41
47
43
4
45
41
4
49
49
2a
2b
48
46
44
42
48
46
42
44

FIG. 8

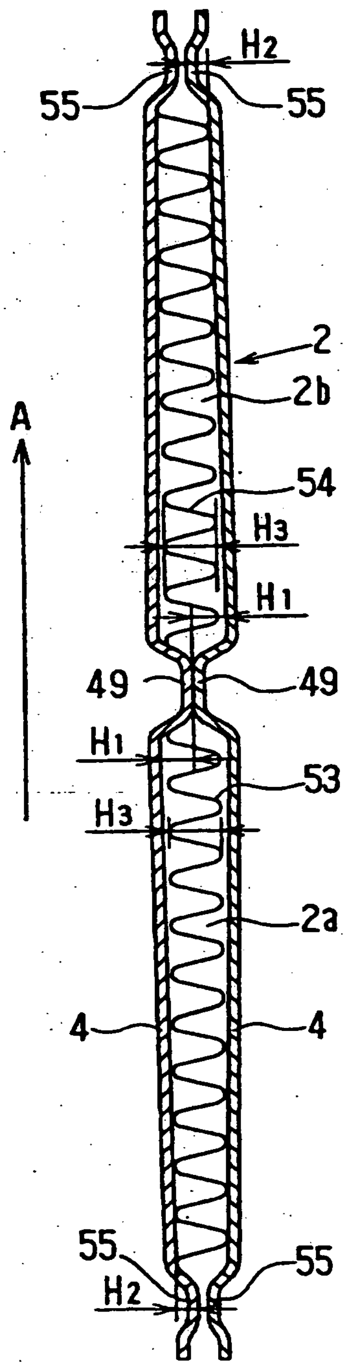


FIG. 9

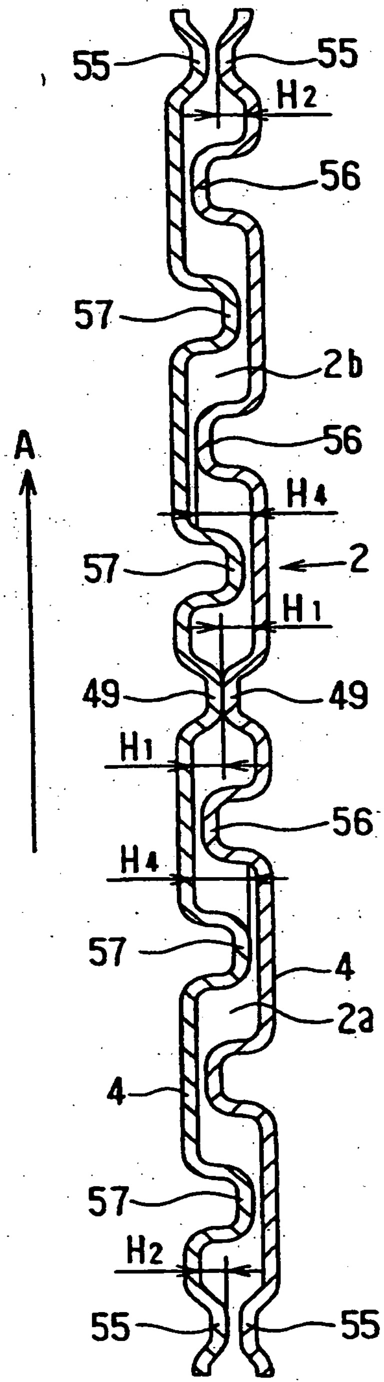
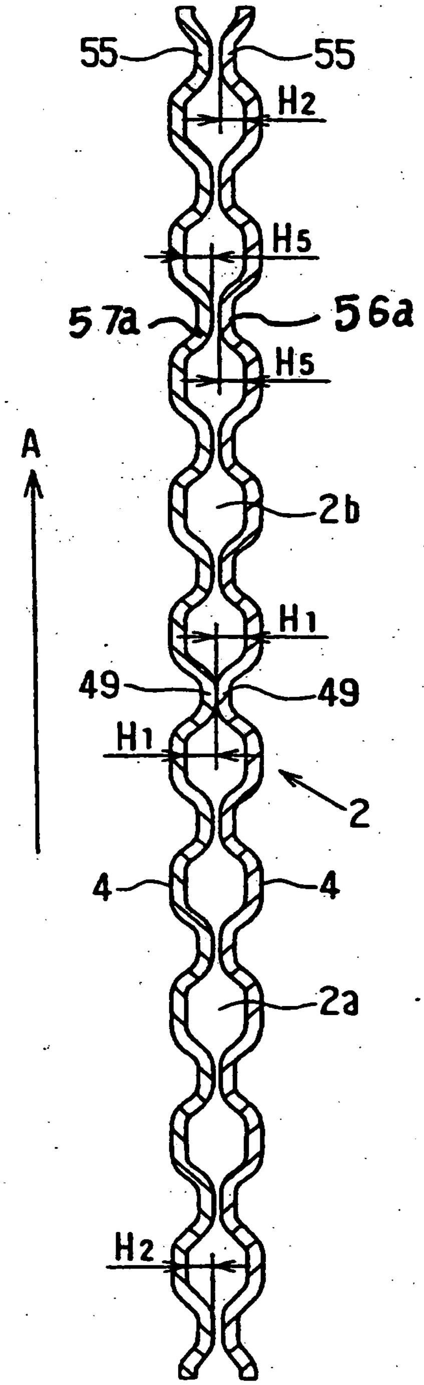


FIG. 10



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HEAT EXCHANGER HAVING A PLURALITY OF TUBES

The present invention relates to a heat exchanger which is constructed by laminating a plurality of tubes made of a pair of metal thin plates, in which a fluid passage inside the tube is partitioned into plural refrigerant passages.

A refrigerant evaporator 1 having a refrigerant route shown in FIG. 6 is disclosed in U.S. Patent Application No. 08/730990. In the evaporator 1, an inlet side heat exchanging portion X is formed at an air down stream side, and an outlet side heat exchanging portion Y is formed at an air upstream side. Here, an arrow A denotes an air flow direction. The inlet side heat exchanging portion X communicates with an upper side inlet tank portion 43 and a lower side inlet tank portion 44. The outlet side heat exchanging portion Y communicates with an upper side outlet tank portion 47 and a lower side outlet tank portion 48. In the heat exchanging portions X and Y, heat exchange between the refrigerant flowing in the evaporator 1 and the air flowing outside the evaporator 1 is carried out. The lower side inlet tank portion 44 is separated into a first inlet tank portion "a" and a second inlet tank portion "b" by a partition plate 51. The upper side outlet tank portion 47 is separated into a first outlet tank portion "c" and a second outlet tank portion "d" by a partition plate 52.

In the evaporator 1, as shown in FIG. 7, a tube 2 through which the refrigerant flows is constructed by connecting a pair

of metal plates 4 to face each other. An inside of the tube 2 is partitioned into an air upstream side refrigerant passage 2a and an air downstream side refrigerant passage 2b by a center rib 49.

In FIG. 6, the refrigerant flows inside the evaporator 1 in accordance with the following route;

"refrigerant inlet pipe 8a → refrigerant passage 15 → first inlet tank portion "a" → air downstream side refrigerant passages 2b → upper side inlet tank portion 43 → air downstream side refrigerant passages 2b → second inlet tank portion "b" → refrigerant passage 13 → first outlet tank portion "c" → air upstream side refrigerant passages 2a → lower side outlet tank portion 48 → air upstream side refrigerant passages 2a → second outlet tank portion "d" → refrigerant passage 14 → refrigerant outlet pipe 8b". Here, in FIG. 6, the refrigerant inlet pipe 8a and the refrigerant outlet pipe 8b are connected to the right side of the evaporator 1. The refrigerant passages 14 and 15 are formed at the right side of the evaporator 1. The refrigerant passage 13 is formed at the left side of the evaporator 1.

In this way, with respect to the air flow A, the outlet side heat exchanging portion Y is disposed at the air upstream side and the inlet side heat exchanging portion X is disposed at the air downstream side. In the inlet side heat exchanging portion X and the outlet side heat exchanging portion Y, the refrigerant flows in the same direction. That is, in FIG. 6, at the right side of the partition plates 51 and 52 in the heat exchanging portions X and Y, the refrigerant flows upwardly, while at the left side of the partition plates 51 and 52, the

refrigerant flows downwardly.

The evaporator 1 is manufactured by laminating th metal plates 4 made of aluminum alloy shown in FIG. 3 to assemble a temporary evaporator structure and brazing it in the brazing furnace. During this brazing step, if the center ribs 49 of the pair of metal plates 4 are not brazed appropriately, the air upstream side refrigerant passage 2a and the air downstream side refrigerant passage 2b communicate with each other directly. Thus, a refrigerant leak occurs at this part and the refrigerant cannot flow as in the predetermined refrigerant flowing route in FIG. 6, then the cooling ability of the evaporator 1 becomes reduced.

The refrigerant leak occurs inside the tube 2, so, the refrigerant leak is called "an internal refrigerant leak". Therefore this internal refrigerant leak cannot be found out in a general refrigerant leak test for finding out an external refrigerant leak in which the refrigerant leaks from the inside of the tube 2 to the outside of the tube 2. In this general external leak test, a test gas is injected into the refrigerant passage inside the evaporator, and after that whether a gas leak from the inside to the outside occurs or not is checked.

A first object of the present invention is, in a heat exchanger which is constructed by laminating a plurality of tubes made of a pair of metal thin plates in which a fluid passage inside the tube is partitioned by a center rib provided on the metal plate, to eliminate a brazing defect at the center rib of

the pair of metal plates for preventing a refrigerant leak at this position (internal r frigerant leak). A second object of the present invention is to provided a heat exchanger in which the internal refrigerant leak caused by the brazing defect can be found easily by a general external refrigerant leak test, even when the center ribs of the pair of metal plates are not brazed sufficiently.

According to the first aspect of the present invention, a distance between the pair of metal plates defined by the center rib is set to be larger than the distance defined by an outer peripheral rib and the distance defined by an inner fin.

Thus, the center ribs of the pair of metal plates are to be contacted and brazed together first of all the other portions, and occurring the internal refrigerant leak at this position is prevented.

Even when the brazing defect occurs between the center ribs of the pair of metal plates, a refrigerant must leak from inside to outside of the tube (external leak), because a gap between the outer peripheral ribs of the pair of metal plates is to become larger than that between the center ribs. Therefore, the internal refrigerant leak can be found as well as the external refrigerant leak by finding out the leak of a test gas from inside to outside of the tube. Accordingly, a defective product can be picked up easily by the general external leak test.

According to the second aspect of the present invention, a distance between the pair of metal plates defined by the center rib is set to be larger than the distance defined by an outer

peripheral rib and the distance defined by a reinforcing rib.

Thus, the center ribs of th pair of metal plates are to be contacted and brazed together first of all the other portions, and occurring the internal refrigerant leak at this position is prevented.

Even when the brazing defect occurs between the center ribs, a refrigerant must leak from inside to outside of the tube (external leak), because a gap between the outer peripheral ribs of the pair of plates is to become larger than that between the center ribs. Therefore, the internal refrigerant leak can be found as well as the external refrigerant leak by finding out the leak of a test gas from inside to outside of the tube. Accordingly, a defective product can be picked up easily by the general external leak test.

Additional objects and advantages of the present invention will be more readily apparent from the following detailed description of preferred embodiments thereof when taken together with the accompanying drawings in which:

FIG. 1 is a perspective view showing the front side of an evaporator according to the present invention;

FIG. 2 is a perspective view showing the back side of an evaporator according to the present invention;

FIG. 3 is a plan view of a metal plate for forming a tube;

FIG. 4 is an enlarged view of the area B in FIGS. 1 and 2;

FIG. 5 is a cross sectional view taken along a line V-V in FIGS. 1 and 2;

FIG. 6 shows a refrigerant flow route in the evaporator according to the present invention;

FIG. 7 is a perspective dealing view showing a tube according to the first embodiment;

FIG. 8 cross sectional view of the tube taken along an air flowing direction according to the first embodiment;

FIG. 9 is a cross sectional view of the tube taken along an air flowing direction according to the second embodiment; and

FIG. 10 is a cross sectional view of the tube taken along an air flowing direction according to the third embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawings, preferred embodiments of the present invention will be described.

(First Embodiment)

An evaporator 1 is disposed in the cooling unit (not illustrated) of an air conditioning apparatus for a vehicle. In FIG. 1, a pipe joint 8 is provided at one end (the left end in FIG. 1 or the right end in FIG. 2) of the evaporator 1. The outlet pipe of a temperature responsive expansion valve (not illustrated) is connected to the refrigerant inlet pipe 8a of the pipe joint 8. A low temperature and low pressure gas-liquid phase refrigerant having been pressure-reduced and expanded by the expansion valve flows into the refrigerant inlet pipe 8a.

The evaporator 1 includes a heat exchanging portion 3. The heat exchanging portion 3 is constructed by a plurality of tubes 2 arranged in parallel and carries out a heat exchange

between the refrigerant flowing inside the tube 2 and an air flowing outside the tube 2. In FIGS. 1 and 2, an arrow A denotes an air flowing direction.

The tube 2 is, as shown in FIG. 7, formed by a pair of metal plates 4 facing each other. As the metal plate 4, brazing sheet (thickness: about 0.4 - 0.6 mm) obtained by cladding an aluminum brazing material (for example A4000) on the two surfaces of an aluminum core material (for example A3000) is used, and the brazing sheet is formed into the shape as shown in FIG. 3. The heat exchanging portion 3 is constructed by laminating a large number of tubes 2 and joining by brazing. Inside the tube 2, an air upstream side refrigerant passage 2a and an air downstream side refrigerant passage 2b are formed in parallel to the longitudinal direction of the metal plate 4.

The metal plate 4 in FIG. 3 is a thin plate for forming the tube 2. At both upper and lower ends of the metal plate 4, an upper side inlet tank portion 43 and a lower side inlet tank portion 44 having a communication hole 41 and 42 respectively are formed. In a similar way, an upper side outlet tank portion 47 and a lower side outlet tank portion 48 having a communication hole 45 and 46 respectively are formed. The communication holes 41 and 42 communicate the air downstream side refrigerant passages 2b of each metal plate to each other, and the communication holes 45 and 46 communicate the air upstream side refrigerant passages 2a of each plate 4 to each other. These tank portions 43, 44, 47 and 48 ar formed into a shape of an ellipse columnar protrusion portions protruding toward the

outside of the metal plate 4. The cross sectional surface area of the inlet tank portions 43 and 44 are set to be smaller than those of the outlet tank portions 47 and 48. In the metal plate 4, a center rib 49 separating the metal plate 4 into the air upstream side refrigerant passage 2a and the air downstream side refrigerant passage 2b is formed. A width dimension of the air upstream side refrigerant passage 2a is the same as that of the air downstream side refrigerant passage 2b.

In the heat exchanging portion 3, a corrugate fin 7 is provided between the adjacent tubes 2. The fin 7 increases the heat transmitting surface area in the air flowing path of the heat exchanging portion 3. The fin 7 is made of an aluminum-bare (for example A3003) not being clad with an aluminum brazing material and formed into a wave shape.

At one end (the left end in FIG. 1 or the right end in FIG. 2) of the heat exchanging portion 3, a side plate 9 and an end plate 10 are provided. The end plate 10 is connected to the side plate 9. At the other end (the right end in FIG. 1 or the left end in FIG. 2) of the heat exchanging portion 3, a side plate 11 and an end plate 12 are provided. The end plate 12 is connected to the side plate 11. These side and end plates 9, 10, 11 and 12 are made of the same brazing sheet as the metal plate 4. Here, the thickness of these plates 9, 10, 11 and 12 are set to be thicker than that of the metal plate 4, for example about 1.0 – 1.6 mm, for providing a sufficient strength.

The end plate 10 (12) is provided with a plurality of protrusion portions 10a (12a) protruding toward the outside of

the heat exchanging portion 3, as shown in FIGS. 4 and 5. The protrusion portions 10a (12a) ar formed into a cross sectional rectangular shape, and are arranged in parallel to the longitudinal direction of the end plate 10 (12). Refrigerant passage 15 (13) (fluid passage) is provided between the protrusion portions 10a (12a) and the flat surface of the side plate 9 (11).

Between the protrusion portions 10a (12a) adjacent to each other, connecting portions 10b (12b) elongating in the longitudinal direction of the end plate 10 (12) are formed. The connecting portions 10b (12b) are connected to the flat surface of the side plate 9 (11).

At the upper and lower ends of the side plate 9, an upper side tank portion 9a and a lower side tank portion 9b are formed respectively. These tank portions 9a and 9b are formed as oval-shaped concave portions elongating in the width direction of the side plate 9. In each upper side tank portion 9a and the lower side tank portion 9b, a communication hole 9c and a communication hole 9d are formed.

At the upper and lower ends of the side plate 11, also, an upper side tank portion 11a and a lower side tank portion 11b are formed respectively. These tank portions 11a and 11b are formed as oval-shaped concave portions elongating in the width direction of the side plate 11. In each upper side tank portion 11a and the lower sid tank portion 11b, a communication hole 11c and a communication hol 11d are formed.

Th lower end of the refrigerant passage 13 communicates with the communication hole 42 in the lower side inlet tank portion 44 through the communication hole 11d of the lower side tank portion 11b. The upper end of the refrigerant passage 13 communicates with the communication hole 45 in the upper side outlet tank portion 47 through the communication hole 11c in the upper side tank portion 11a.

In the end plate 10, as shown in FIG. 1, the protrusion portion 10a is formed below the pipe joint 8, and a stage portion 10c is formed above the pipe joint 8. The stage portion 10c is formed as an oval-shaped convex portion.

Between the inside of the stage portion 10c and the side plate 9, a refrigerant passage 14 (see FIG. 6) is provided. The protrusion portion 10a and the stage portion 10c are arranged such that the refrigerant in the refrigerant passage 15 and the refrigerant in the refrigerant passage 14 do not communicate.

The refrigerant passage 14 communicates with the communication hole 45 in the upper side outlet tank portion 47 through the communication hole (not illustrated) in the outlet tank portion 9a of the side plate 9, and with the refrigerant outlet pipe 8b of the pipe joint 8. The upper end of the refrigerant passage 15 communicates with the refrigerant inlet pipe 8a of the pipe joint 8, while the lower end of th refrigerant passage 15 communicates with the communication hole 42 in the lower side inlet tank portion 44 through the communication hole (not illustrated) in the inlet tank portion 9b of the side plate 9.

Here, the shapes of the outlet tank portion 9a and the inlet tank portion 9b are the same as that of the upper side and lower side tank portions 11a and 11b of the side plate 11.

The pipe joint 8 is made of an aluminum bare (for example A6000), and the refrigerant inlet pipe 8a and the refrigerant outlet pipe 8b are integrated with the pipe joint 8. Each end portion of the refrigerant inlet pipe 8a and the refrigerant outlet pipe 8b is inserted into the hole (not illustrated) of the end plate 10 and fixed to this by brazing. To the refrigerant inlet pipe 8a, the outlet side refrigerant pipe of the expansion valve is connected, while to the refrigerant outlet pipe 8b, a compressor suction pipe which introduces the gas phase refrigerant evaporated by the evaporator 1 into the compressor is connected.

FIG. 6 is a schematic perspective view of the refrigerant passage route in the evaporator 1, which is corresponding to the view of FIG. 2. At the predetermined position inside the lower side inlet tank portion 44, a first partition plate 51 is disposed, while at the predetermined position inside the upper side outlet tank portion 47, a second partition plate 52 is disposed. The first partition plate 51 is formed by closing the communication hole 42 in the lower side inlet tank portion 44 of the metal plate 4. The second partition plate 52 is formed by closing the communication hole 45 in the upper outlet side tank portion 47 of the metal plate 4.

By disposing the first partition plate 51, the lower side inlet tank portion 44 is separated into a first inlet tank

portion "a" and a second inlet tank portion "b". By disposing the second partition plate 52, the upper side outlet tank portion 47 is separated into a first outlet tank portion "c" and a second outlet tank portion "d".

According to the above-described structure, the refrigerant flows inside the evaporator 1 in accordance with the following route,

"refrigerant inlet pipe 8a → refrigerant passage 15 → first inlet tank portion "a" → air downstream side refrigerant passages 2b → upper side inlet tank portion 43 → air downstream side refrigerant passages 2b → second inlet tank portion "b" → refrigerant passage 13 → first outlet tank portion "c" → air upstream side refrigerant passages 2a → lower side outlet tank portion 48 → air upstream side refrigerant passages 2a → second outlet tank portion "d" → refrigerant passage 14 → refrigerant outlet pipe 8b".

In this way, a temperature of the air flowing in the direction of the arrow A at the downstream side of the evaporator 1 is equalized in the entire area of the heat exchanging portion 3.

The assembling step of the evaporator 1 according to th present embodiment will be explained.

At first, the metal plate 4, corrugate fin 7, side plates 9 and 11, and the end plates 10 and 12 are stacked, and after that, the pipe joint 8 is connected to the end plat 10. In this way, a temporary assembly of a predetermined structure of the evaporator 1 showed in FIGS. 1 and 2 is provided.

Next, by binding the temporarily assembled structure of the evaporator 1 from the outsides of the end plates 10 and 12 tightly with wires 60 and 61, the temporarily assembled condition of the evaporator 1 is held.

Finally, the temporarily assembled structure of the evaporator 1 is carried into a brazing furnace and heated to the melting point of the aluminum brazing material, then each connecting part of the temporarily assembled structure of the evaporator 1 is fixed by brazing.

Here, according to the present embodiment, for finding an internal refrigerant leak caused by a brazing defect at the center rib 49 which partitions the air upstream side refrigerant passage 2a and the air downstream side refrigerant passage 2b inside the tube 2, the following featured structure is adopted.

FIG. 8 is a cross sectional view of the tube 2 taken along an air flowing direction (the direction perpendicular to the longitudinal direction of the tube 2). In FIG. 8, an inner fin 53 and an inner fin 54 are provided in the air upstream side refrigerant passage 2a and the air downstream side refrigerant passage 2b respectively for increasing the heat transmitting efficiency of the refrigerant, and reinforcing the tube 2 in its thickness direction (the right and left direction in FIG. 8). The inner fins 53 and 54 are made of an aluminum bare (for example A3003) not being clad with an aluminum brazing material and formed into a wave shape. The inner fins 53 and 54 are connected to the inside surface of the metal plate 4 forming the tube 2.

At the outer periphery of the metal plate 4, an outer peripheral rib 55 is formed in all round, and the height thereof is uniform in all round.

Here, the height H1 of the center rib 49, the height H2 of the outer peripheral rib 55, and the heights H3 of the inner fins 53 and 54 are set to be as follows.

That is, the distance ($2 \times H1$) between the pair of metal plates 4 defined by the center ribs 49 is set to be larger than the distance ($2 \times H2$) between the pair of metal plates 4 defined by the outer peripheral ribs 55 and the distance (H3) between the pair of metal plates 4 defined by the inner fins 53 and 54. In short, the dimensions of each part of the tube 2 are set to provide the following relations:

$(2 \times H1) > (2 \times H2)$, and $(2 \times H1) > H3$.

Here, for example, above each dimension is set to be as follows:

H1 = 0.92 mm, H2 = 0.87 mm, and H3 = 1.76 mm.

Accordingly, in this case, the relations "$(2 \times H1) > H3 > (2 \times H2)$" are provided.

In this way, by setting the dimensions of each part of the tube 2 to provide the relations "$(2 \times H1) > (2 \times H2)$, and $(2 \times H1) > H3$", when the evaporator 1 is temporarily assembled, the center ribs 49 of the pair of metal plates 4 is to be contacted with each other prior to the ridge of the inner fins 53, 54 and the inside surfaces of the metal plate 4, and to the outer peripheral ribs 55 of the pair of metal plates 4.

Therefore, when the temporarily assembled evaporator is

carried to the brazing furnace, the center ribs 49 of the pair of metal plates 4 are contacted firmly with each oth r, accordingly the contacted portion is to be brazed prior to the other portions and the internal refrigerant leak at this position is prevented.

Even when there arises a gap between the ribs 49 of the pair of metal plates 4, because a gap between the outer peripheral ribs 55 must become larger than that between the center ribs 49, the refrigerant leaks from inside to outside the tube 2 (external leak). Therefore, the internal refrigerant leak can be found as an external refrigerant leak by finding out a leak of a test-gas through the gap between the outer peripheral ribs 55. That is, a defective product can be picked up easily by a general external leak test.

(Second Embodiment)

In the second embodiment, as shown in FIG. 9, reinforcing ribs 56 and 57 are formed inside the tube 2, and the inner fins 53 and 54 in the first embodiment are eliminated. The reinforcing ribs 56 and 57 are protruded from the pair of metal plates 4 toward the inside of the air upstream side refrigerant passage 2a and the air downstream side refrigerant passage 2b.

The reinforcing ribs 56 and 57 are constructed by plural small projections formed into a U-shape in cross section, and arranged in a refrigerant flowing direction inside the refrigerant passages 2a and 2b for increasing the heat transmitting efficiency of the refrigerant flowing ther through. Further, when the evaporator assembly is brazed, the top surface of the reinforcing ribs 56 and 57 contact to their opposite

inside surface of the metal plates 4 to reinforc the tube 2.

According to the second embodiment, also, the heights H4 of the reinforcing ribs 56 and 57 are set to be as follows.

That is, the distance ($2 \times H1$) between the pair of metal plates 4 defined by the center ribs 49 is set to be larger than the distance ($2 \times H2$) between the pair of metal plates 4 defined by the outer peripheral ribs 55 and the distance (H4) between the pair of metal plates 4 defined by the reinforcing ribs 56 and 57. In short, the dimensions of each part of the tube 2 are set to provide the following relations:

$(2 \times H1) > (2 \times H2)$, and $(2 \times H1) > H4$.

In this way, by setting the dimensions of each part of the tube 2 to provide the above relations, when the evaporator 1 is temporarily assembled, the center ribs 49 of the pair of metal plates 4 is to be contacted with each other prior to the top surfaces of the inner reinforcing ribs 56, 57 and their opposite inside surface of the metal plate 4, and to the outer peripheral ribs 55 of the pair of metal plates 4. By this, in the second embodiment, the same effect as in the first embodiment is attained.

Here, for example, above each dimension is set to be as follows:

$H1 = 0.92$ mm, $H2 = 0.87$ mm, and $H4 = 1.76$ mm.

Accordingly, in this case, the relations "$(2 \times H1) > H4 > (2 \times H2)$" are provided.

(Third Embodiment)

In the second embodiment, the reinforcing ribs 56 and 57

have enough heights to contact their opposite inside surface of the metal plates 4. Whereas, according to the present third embodiment, as shown in FIG. 10, reinforcing ribs 56a and 57a are provided in the pair of metal plates 4 in such a manner that the top surfaces of the reinforcing ribs 56a and 57a face and contact to each other. In the third embodiment, also, the heights H5 of the reinforcing ribs 56a and 57a are set to be as follows.

That is, the distance $(2 \times H1)$ between the pair of metal plates 4 defined by the center ribs 49 of them is set to be larger than the distance $(2 \times H2)$ between the pair of metal plates 4 defined by the outer peripheral ribs 55 of them and the distance $(2 \times H5)$ between the pair of metal plates 4 defined by the reinforcing ribs 56a and 57a. In short, the dimensions of each part of the tube 2 are set to provide the following relations:

$(2 \times H1) > (2 \times H2)$, and $(2 \times H1) > (2 \times H5)$.

In this way, by setting the dimensions of each part of the tube 2 to provide the above relations, when the evaporator 1 is temporarily assembled, the center ribs 49 of the pair of metal plates 4 is to be contacted with each other prior to the top surfaces of the reinforcing ribs 56a and 57a, and to the outer peripheral ribs 55 of the pair of metal plates 4. By this, in the present third embodiment, the same effect as in the first embodiment is attained.

Here, for example, above each dimension is set to be as follows:

$H1 = 0.92$ mm, $H2 = 0.87$ mm, and $H4 = 0.88$ mm.

Accordingly, in this case, the relations "(2 × H1) > (2 × H5) > (2 × H2)" are provided.

Here, the main object of the present invention is to prevent the internal refrigerant leak at the part inside the tube 2 partitioned by the center ribs 49 and make it easy to find out the internal refrigerant leak. Therefore, the refrigerant flowing route in the heat exchanging portion 3 is not limited to the above embodiments showed in FIG. 6, and many modifications can be applied.

In the metal plate 4, as shown in FIG. 3, the center ribs 49 are provided at the center in the width direction of the metal plate 4, and the width dimensions of the refrigerant passages 2a and 2b are set to be equal. However, it should be noted that the center ribs 49 can be provided at the location being set off with respect to the center position.

In the above first through third embodiments, the center ribs 49 and the outer peripheral ribs 55 are formed in both of the pair of metal plates 4 such that the top surfaces of the center ribs 49 and the outer peripheral ribs 55 contact each other. In the other way, as shown in FIG. 9, forming the center rib 49 and the outer periphery rib 55 on the only one metal plate of the pair of metal plates 4 and contacting these ribs 49 and 55 to the inside surface of the other metal plate 4 are possible.

The heat exchanger of the present invention is not limited to be applied only to a refrigerant evaporator only and can applied to another heat exchangers carrying out heat exchanges between several kinds of fluid.

WHAT IS CLAIMED IS

1. A heat exchanger comprising:

a plurality of tubes arranged in parallel in which plural fluid passages are formed, said tube being constructed by a pair of metal plates connected to face each other, at least one of said pair of metal plates having an outer peripheral rib at an outer periphery thereof and a center rib for partitioning said plural passages; and

an inner fin disposed in said plural fluid passages, wherein

said tube is formed by connecting said pair of metal plates at a position of said outer peripheral rib and a position of said center rib,

said plural fluid passages of each tube communicate with each other, and

a distance between said pair of metal plates defined by said center rib is larger than the distance defined by said outer peripheral rib and the distance defined by said inner fin.

2. A heat exchanger according to claim 1, wherein

said outer peripheral rib is provided at outer periphery of both metal plates constructing said tube such that heights thereof are equal to each other,

said center rib is provided in said both metal plates such that heights thereof are equal to each other,

the height of said center rib is larger than the height of

said outer peripheral rib, and

the height of said center rib is larger than a half of a height of said inner fin.

3. A heat exchanger comprising:

a plurality of tubes arranged in parallel in which plural fluid passages are formed, said tube being constructed by a pair of metal plates connected to face each other, at least one of said pair of metal plates having an outer peripheral rib at an outer periphery thereof, a center rib for partitioning said plural passages and plural reinforcing ribs in such a manner that they protrude toward an inside of said plural fluid passages; and

an inner fin disposed in said plural fluid passages, wherein

said tube is formed by connecting said pair of metal plates at a position of said outer peripheral rib, a position of said center rib, and positions of said reinforcing ribs,

said plural fluid passages of each tube communicate with each other, and

a distance between said pair of metal plates defined by said center rib is larger than the distance defined by said outer peripheral rib and the distance defined by said reinforcing ribs.

4. A heat exchanger according to claim 3, wherein said reinforcing rib provided in one of said pair of metal plates contacts to an opposite inside surface of the other metal plate.

5. A heat exchanger according to claim 3, wherein

said reinforcing rib is provided in both of said pair of metal plates and top surfaces thereof are contacted with each other.

6. A heat exchanger according to claim 1, wherein

said heat exchanger is a refrigerant evaporator in which a heat exchange between air flowing outside of said heat exchanger and refrigerant of a refrigerant cycle flowing inside of said heat exchanger is carried out,

said plural fluid passages are constituted of an air upstream side refrigerant passage and an air downstream side refrigerant passage,

at both ends of said tube in its longitudinal direction, tank portions are provided for communicating said air upstream side refrigerant passages and said air downstream side refrigerant passages of each tube to each other respectively.

7. A heat exchanger substantially as described herein with reference to the accompanying drawings.

The Patent Office

Application No: GB 9803838.3	**Examiner:** Tim James
Claims searched: 1-7	**Date of search:** 10 July 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F4S (S2M4, S4JX)

Int Cl (Ed.6): F25B (39/02); F28F (3/12, 3/14); F28D (1/03)

Other: On-line databases: WPI; EPODOC

D cuments considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0556433 A1 (Miralfin) see figure 3	—

X	Document indicating lack of novelty or inventive step	**A**	Document indicating technological background and/or state of the art.
Y	Document indicating lack f inventive step if combined with one or more other documents of same category.	**P**	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		

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